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LOOKOUT SHOALS LAKE ALEXANDER, CATAWBA AND IREDELL COUNTIES, NORTH CAROLINA

Pacific Northwest Environmental Research Laboratory

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June 1975

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
LOOKOUT SHOALS LAKE
ALEXANDER, CATAWBA
AND IREDELL COUNTIES
NORTH CAROLINA
EPA REGION IV
WORKING PAPER No. 385

WITH THE COOPERATION OF THE

NORTH CAROLINA DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES

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JUNE, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the North Carolina Department of Natural and Economic Resources for professional involvement and to the North Carolina National Guard for conducting the tributary sampling phase of the Survey.

Lewis R. Martin, Director of the Division of Environmental Management; Darwin L. Coburn, Chief of the Water Quality Section; and Julian R. Taylor, Supervisor of the Monitoring Program Unit; provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

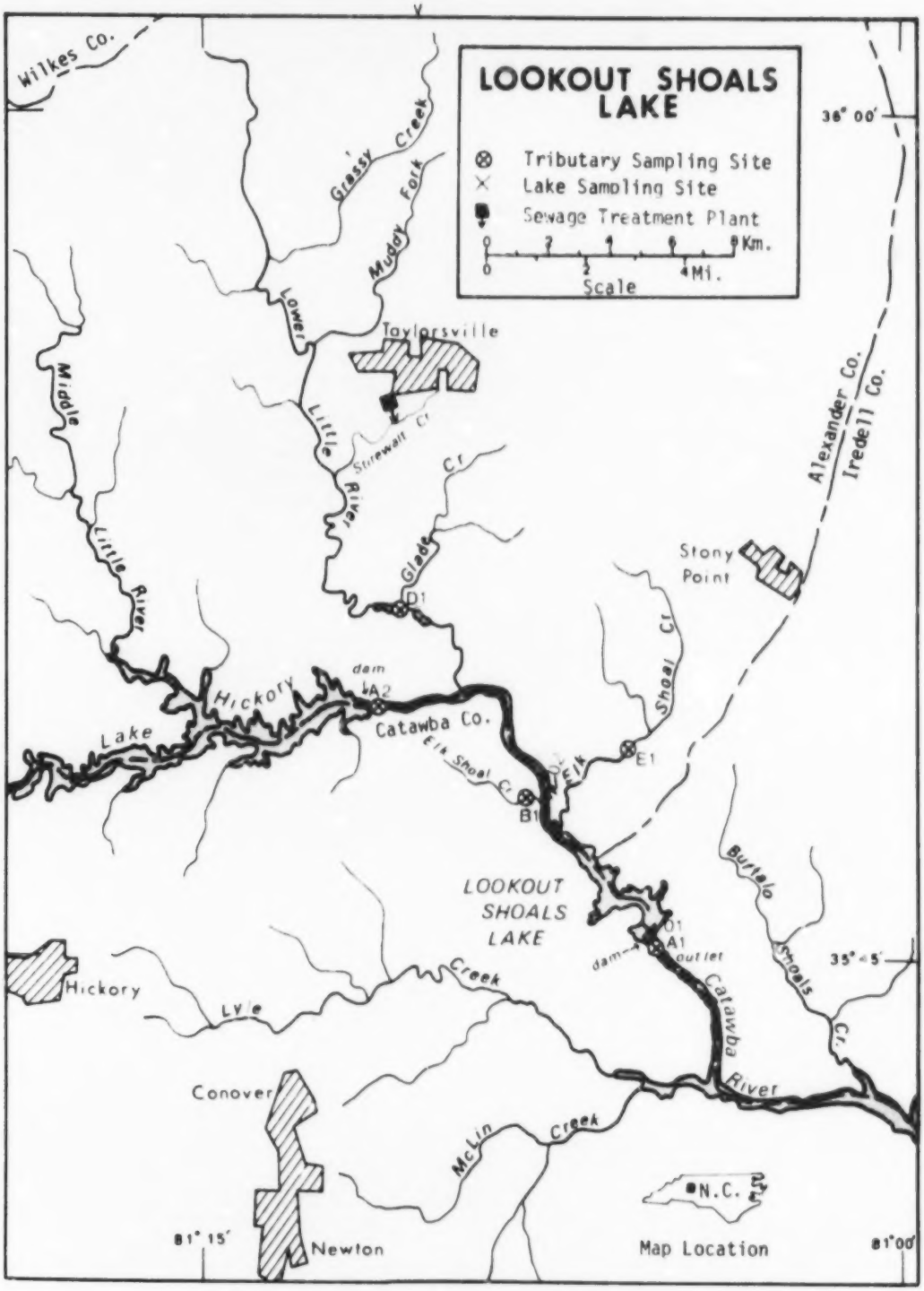
Major General William M. Buck, formerly Adjutant General of North Carolina, and Project Officer Colonel Arthur J. Bouchard, who directed the volunteer efforts of the North Carolina National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF NORTH CAROLINA

LAKE NAME	COUNTY
Badin	Montgomery, Stanly
Blewett Falls	Anson, Richmond
Chatuge	Clay, NC; Towns, GA
Fontana	Graham, Swain
Hickory	Alexander, Caldwell, Catawba
High Rock	Davidson, Rowan
Hiwassee	Cherokee
James	Burke, McDowell
John H. Kerr (Nut Bush Creek)	Granville, Vance, Warren, NC; Halifax, Mecklenburg, VA
Junaluska	Haywood
Lookout Shoals	Alexander, Catawba, Iredell
Mountain Island	Gaston, Mecklenburg
Norman	Catawba, Iredell, Lincoln, Mecklenburg
Rhodhiss	Burke, Caldwell
Santeetlah	Graham
Tillery	Montgomery, Stanly
Waccamaw	Columbus
Waterville	Haywood
Wylie	Gaston, Mecklenburg, NC; York, SC


LOOKOUT SHOALS LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Plant
0 2 4 6 8 Km.
0 2 4 Mi.
Scale
Wilkes Co.
Grassy Creek
Muddy Fork
Lower
Middle
Little River
Taylorsville
Strikewall Cr
Glade Cr
Little River
D1
Stony Point
Alexander Co.
Iredell Co.
36° 00'
Shoal Cr
dam
A2
Hickory
Lake
Catawba Co.
E1A Shoal Cr
E1A
E1
B1
LOOKOUT SHOALS LAKE
D1
A1
outlet
dam
Buffalo Shoals Cr.
35° 45'
Hickory
Lyle Creek
Catawba River
Conover
McLin Creek
N.C.
Map Location
81° 15'
Newton
81°00'

LOOKOUT SHOALS LAKE

STORET NO. 3710

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lookout Shoals Lake is eutrophic. However, because the lake has a mean hydraulic retention time of only seven days, it is nearly a free-flowing stream; and the term "over-enriched" may be a more appropriate description of the condition of the lake.

Lookout Shoals Lake ranked eighth in overall trophic quality when the 14 North Carolina lakes sampled in 1973 were compared using a combination of six parameters*. Seven of the lakes had less median total phosphorus, seven had less and two had the same median dissolved phosphorus, eight had less median inorganic nitrogen, five had less mean chlorophyll a, and six had greater mean Secchi disc transparency.

Survey limnologists observed submerged aquatic vegetation along the shoreline. Dissolved oxygen depression and a four- to six-fold increase in chlorophyll a, along with significant increases in phytoplankton numbers (see page 7), occurred in July and September.

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* See Appendix A.

B. Rate-Liming Nutrient:

The algal assay results indicate that Lookout Shoals Lake was limited by phosphorus at the time the sample was collected 03/30/73). The lake data substantiate phosphorus limitation; i.e., the mean N/P ratios were 27/1 or greater at all stations and sampling times.

C. Nutrient Controllability:

1. Point sources--During the sampling year, the only known point source, the Taylorsville wastewater treatment plant, contributed 1.8% of the total phosphorus load to Lookout Shoals Lake.

The present phosphorus loading rate of 18.52 $g/m^2/yr$ is 4.5 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic rate (see page 13). Although Vollenweider's model may not be applicable to lakes with short hydraulic retention times, the existing trophic condition of the lake is evidence of excessive nutrient loads.

Since Lookout Shoals Lake is phosphorus limited, any reduction of phosphorus inputs should result in at least some improvement in the trophic condition of the lake. However, it is likely that a significant improvement is dependent on point-source phosphorus control upstream in the Catawba River drainage (see Working Paper No. 380 "Report on Lake Hickory").

An apparent loss of phosphorus occurred during the sampling year (see page 11). This would not be expected to occur and may be indicative of unmeasured point sources discharging directly to the lake. Also note that the apparent loss amounts to less than 0.5% of the total load and is within the error range of the loading calculations. Since the reservoir has a mean hydraulic retention time of only 7 days, a high retention of phosphorus would not be expected in any case.

2. Non-point sources--The phosphorus contribution of non-point sources accounted for 98.2% of the total input to Lookout Shoals Lake. The Catawba River contributed 93.1%, the Lower Little River contributed 3.5%, and the remaining tributaries contributed 0.7% of the total phosphorus load, collectively. Ungaged tributaries were estimated to have contributed a total pf 0.8%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 4.14 kilometers^2.
2. Mean depth: 9.3 meters.
3. Maximum depth: >18.3 meters.
4. Volume: 38.5 x 10^6 m^3.
5. Mean hydraulic retention time: 7 days (based on outlet flow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Catawba River	3,392.9	53.0
Elk Shoal Creek (B-1)	13.7	0.2
Lower Little River	259.0	2.6
Elk Shoal Creek (E-1)	41.4	0.4
Minor tributaries & immediate drainage -	44.4	0.7
Totals	3,751.4	56.9

2. Outlet -

Catawba River	3,755.5**	60.5

C. Precipitation***:

1. Year of sampling: 148.9 centimeters.
2. Mean annual: 119.9 centimeters.

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† Table of metric conversions--Appendix B.
†† Park, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lookout Shoals Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 18.3 meters at station 1 and 3.4 meters at station 2.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LOOKOUT SHOALS
STORET CODE 3710

PARAMETER	1ST SAMPLING (3/30/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/ 7/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/24/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	11.8 - 12.6	12.2	12.2	22.6 - 26.9	24.0	23.4	23.2 - 25.3	23.8	23.6
DISS OXY (MG/L)	8.6 - 9.0	8.8	8.8	1.2 - 7.5	4.7	4.8	3.4 - 8.2	5.8	4.8
CNDCTVY (MCROMO)	50. - 50.	50.	50.	55. - 60.	57.	55.	46. - 49.	48.	48.
PH (STAND UNITS)	7.2 - 7.7	7.5	7.6	6.3 - 7.1	6.6	6.5	6.4 - 7.7	6.8	6.6
TOT ALK (MG/L)	10. - 10.	10.	10.	12. - 23.	17.	18.	15. - 19.	18.	18.
TOT P (MG/L)	0.059 - 0.072	0.065	0.065	0.019 - 0.044	0.025	0.023	0.018 - 0.030	0.024	0.025
ORTHO P (MG/L)	0.011 - 0.019	0.013	0.012	0.005 - 0.009	0.007	0.006	0.006 - 0.011	0.008	0.007
NO2+NO3 (MG/L)	0.260 - 0.270	0.267	0.270	0.160 - 0.200	0.184	0.180	0.120 - 0.140	0.130	0.130
AMMONIA (MG/L)	0.110 - 0.140	0.132	0.140	0.090 - 0.330	0.169	0.160	0.180 - 0.210	0.155	0.155
KJEL N (MG/L)	0.300 - 0.600	0.362	0.300	0.200 - 0.500	0.300	0.250	0.400 - 1.500	0.683	0.500
INORG N (MG/L)	0.370 - 0.410	0.400	0.410	0.260 - 0.490	0.352	0.350	0.240 - 0.330	0.285	0.280
TOTAL N (MG/L)	0.560 - 0.860	0.630	0.570	0.380 - 0.660	0.484	0.440	0.520 - 1.640	0.813	0.630
CHLRPYL A (UG/L)	1.5 - 1.7	1.6	1.6	2.8 - 3.6	2.8	2.8	6.0 - 10.4	8.2	8.2
SECCHI (METERS)	0.5 - 0.5	0.5	0.5	1.0 - 1.5	1.3	1.3	0.9 - 1.8	1.4	1.4

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal units per ml
03/30/73	1. Melosira	613
	2. Lyngbya	123
	3. Pennate diatoms	46
	4. Mallomonas	46
	5. Scenedesmus	15
	Other genera	93
	Total	936
07/07/73	1. Cyclotella	318
	2. Lyngbya	258
	3. Flagellates	238
	4. Chlamydomonas	200
	5. Kirchneriella	200
	Other genera	1,226
	Total	2,440
09/24/73	1. Raphidiopsis	1,781
	2. Chroococcus	1,233
	3. Microcystis	987
	4. Lyngbya	658
	5. Kirchneriella	384
	Other genera	1,260
	Total	6,303

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
03/30/73	01	1.7
	02	1.5
07/07/73	01	3.6
	02	2.0
09/24/73	01	10.4
	02	6.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.020	0.492	1.6
0.050 P	0.070	0.492	8.8
0.050 P + 1.0 N	0.070	1.492	22.3
1.0 N	0.020	1.492	1.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lookout Shoals Lake was moderate at the time the sample was collected (03/30/73). Also, the five-fold increase in yield when phosphorus was added indicates that the body of water was limited by phosphorus at that time. Note that the addition of only nitrogen resulted in a yield not significantly different than that of the control.

The lake data substantiate phosphorus limitation; i.e., the mean N/P ratios were 27/1 or greater at all stations and sampling times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the North Carolina National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of January and February when two samples were collected. Sampling was begun in March, 1973, and was completed in February, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the North Carolina District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations B-1 and E-1 and multiplying the means by the ZZ area in km^2.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Taylorsville*	1,231	trickling	465.9**	Stirewalt Creek

2. Known industrial - None

* Anonymous, 1971; population shown is 1970 census.
** Flow estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Catawba River	71,355	93.1
Elk Shoal Creek (B-1)	245	0.3
Lower Little River	2,690	3.5
Elk Shoal Creek (E-1)	325	0.4
b. Minor tributaries & immediate drainage (non-point load) -	575	0.8
c. Known municipal STP's -		
Taylorsville	1,395	1.8
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	70	0.1
Total	76,655	100.0

2. Outputs -

Lake outlet - Catawba River	77,025

3. Net annual P loss - 370 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Catawba River	1,155,610	91.8
Elk Shoal Creek (B-1)	6,105	0.5
Lower Little River	65,980	5.3
Elk Shoal Creek (E-1)	8,195	0.6
b. Minor tributaries & immediate drainage (non-point load) -	14,275	1.1
c. Known municipal STP's -		
Taylorsville	4,185	0.3
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	4,470	0.4
Total	1,258,830	100.0

2. Outputs -

Lake outlet - Catawba River 1,242,605

3. Net annual N accumulation - 16,225 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Catawba River	21	341
Elk Shoal Creek (B-1)	18	446
Lower Little River	10	255
Elk Shoal Creek (E-1)	8	198

* See Working Paper No. 175.

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	18.52	loss*	304.1	3.9

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lookout Shoals Lake:

"Dangerous" (eutrophic rate)	4.10
"Permissible" (oligotrophic rate)	2.05

* There was an apparent loss of phosphorus during the sampling year. This would not be expected even in a lake with a retention time of only seven days. The loss may be have been due to solubilization of previously sedimented phosphorus, unknown and unsampled point sources discharging directly to the lake, or may have been within the error of the loading estimates since the difference is very small.

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 4, Washington, DC.

Park, Dave, 1974. Personal communication (lake morphometry). NC Dept. of Nat. & Econ. Resources, Raleigh.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Weiss, Charles M., 1972. A proposal to the Water Resources Research Institute of the University of North Carolina. The trophic state of North Carolina lakes, covering the period July 1, 1972 to June 30, 1973. U. of North Carolina, Chapel Hill.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3719	LAKE WACCAMAW	534
2	3716	SANTEELAH LAKE	446
3	3711	MOUNTAIN ISLAND LAKE	419
4	3707	HIWASSEE LAKE	414
5	3704	FONTANA LAKE	392
6	3713	LAKE NORMAN	346
7	3708	LAKE JAMES	334
8	3710	LOOKOUT SHOALS	327
9	3715	RHODHISS LAKE	296
10	3705	LAKE HICKORY	283
11	3717	LAKE TILLERY	246
12	3709	LAKE JUNALUSKA	220
13	3702	BLEWETT FALLS LAKE	200
14	3718	WATERVILLE RESERVOIR	140
15	3701	BADIN LAKE	124
16	3706	HIGH ROCK LAKE	76

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SOL- MEAN SEC	MEAN CHLORA	IS- MIN DO	MEDIAN DISS ORTHO P
3701	BADIN LAKE	0.042	0.680	466.750	7.190	14.900	0.012
3702	BLEWETT FALLS LAKE	0.099	0.655	476.889	4.167	10.800	0.034
3704	FONTANA LAKE	0.011	0.550	392.650	3.438	14.900	0.007
3705	LAKE HICKORY	0.047	0.320	461.000	7.275	13.400	0.008
3706	HIGH ROCK LAKE	0.040	0.580	477.454	14.283	14.800	0.017
3707	HIWASSEE LAKE	0.015	0.240	420.555	5.678	14.200	0.007
3708	LAKE JAMES	0.020	0.160	428.866	7.660	14.800	0.006
3709	LAKE JUNALUSKA	0.031	0.360	462.000	7.233	14.200	0.009
3710	LOOKOUT SHOALS	0.025	0.370	459.167	4.200	13.800	0.008
3711	MOUNTAIN ISLAND LAKE	0.014	0.270	462.000	5.580	12.800	0.005
3713	LAKE NORMAN	0.014	0.330	446.667	5.867	14.800	0.005
3715	RHODHISS LAKE	0.061	0.305	462.111	3.578	13.600	0.019
3716	SANTEELAH LAKE	0.011	0.160	366.400	5.360	14.800	0.006
3717	LAKE TILLERY	0.040	0.470	468.600	6.827	13.600	0.008
3718	WATERVILLE RESERVOIR	0.103	0.860	468.333	3.817	14.400	0.041
3719	LAKE WACCAMAW	0.014	0.120	455.667	3.583	9.800	0.004

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3701	BADIN LAKE	33 (5)	7 (1)	27 (4)	27 (4)	3 (0)	27 (4)	124
3702	BLEWETT FALLS LAKE	7 (1)	13 (2)	7 (1)	73 (11)	93 (14)	7 (1)	200
3704	FONTANA LAKE	100 (15)	33 (5)	93 (14)	100 (15)	3 (0)	63 (9)	392
3705	LAKE HICKORY	27 (4)	60 (9)	53 (8)	13 (2)	80 (12)	50 (7)	283
3706	HIGH ROCK LAKE	13 (2)	20 (3)	0 (0)	0 (0)	23 (2)	20 (3)	76
3707	HIWASSEE LAKE	87 (13)	80 (12)	87 (13)	47 (7)	50 (7)	63 (9)	414
3708	LAKE JAMES	60 (9)	87 (13)	80 (12)	7 (1)	23 (2)	77 (11)	334
3709	LAKE JUNALUSKA	47 (7)	27 (4)	43 (6)	20 (3)	50 (7)	33 (5)	220
3710	LOOKOUT SHOALS	53 (8)	47 (7)	60 (9)	67 (10)	60 (9)	40 (6)	327
3711	MOUNTAIN ISLAND LAKE	73 (11)	73 (11)	43 (6)	53 (8)	87 (13)	90 (13)	419
3713	LAKE NORMAN	67 (10)	53 (8)	73 (11)	40 (6)	23 (2)	90 (13)	346
3715	RHODHISS LAKE	20 (3)	67 (10)	33 (5)	93 (14)	70 (10)	13 (2)	296
3716	SANTEELAH LAKE	93 (14)	93 (14)	100 (15)	60 (9)	23 (2)	77 (11)	446
3717	LAKE TILLERY	40 (6)	40 (6)	13 (2)	33 (5)	70 (10)	50 (7)	246
3718	WATERVILLE RESERVOIR	0 (0)	0 (0)	20 (3)	80 (12)	40 (6)	0 (0)	140
3719	LAKE WACCAMAW	80 (12)	100 (15)	67 (10)	87 (13)	100 (15)	100 (15)	534

APPENDIX B

CONVERSIONS FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NORTH CAROLINA 10/21/75

LAKE CODE 3710 LOOKOUT SHOALS RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 1450.00

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3710A1	1450.00	2350.00	2460.00	2700.00	2070.00	2050.00	1980.00	1740.00	1940.00	1740.00	2180.00	2050.00	2380.00	2135.95
3710A2	1310.00	2040.00	2130.00	2340.00	1790.00	1780.00	1760.00	1530.00	1690.00	1520.00	1930.00	1830.00	2110.00	1870.30
3710B1	5.30	8.80	12.00	12.00	11.00	8.00	7.00	5.60	6.30	6.40	6.90	6.00	7.70	8.12
3710D1	100.00	97.00	134.00	143.00	158.00	93.00	83.00	66.00	60.00	62.00	69.00	63.00	88.00	92.68
3710E1	16.00	15.00	16.00	17.00	18.00	14.00	12.00	10.00	9.00	9.00	10.00	9.50	13.00	12.69
3710Z2	18.70	27.00	37.00	38.00	38.00	25.00	22.00	18.00	18.00	19.00	20.00	18.00	24.00	25.25

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 1450.00
SUM OF SUB-DRAINAGE AREAS = 1450.00

TOTAL FLOW IN = 24120.19
TOTAL FLOW OUT = 25640.00

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3710A1	3	73	5800.00	24	4720.00				
	4	73	5170.00	15	2140.00				
	5	73	5170.00	20	1180.00				
	6	73	3600.00	23	2080.00				
	7	73	2600.00	24	2210.00				
	8	73	3270.00	19	3140.00				
	9	73	2240.00	9	485.00				
	10	73	1960.00	21	105.00				
	11	73	1630.00	18	105.00				
	12	73	3270.00	16	2320.00				
	1	74	4060.00	5	4950.00	19	3280.00		
	2	74	3470.00	9	780.00	24	3940.00		
3710A2	3	73	5380.00	24	4890.00				
	4	73	4640.00	15	1200.00				
	5	73	4810.00	20	1040.00				
	6	73	3410.00	23	1930.00				
	7	73	2450.00	24	2300.00				
	8	73	3100.00	19	2960.00				
	9	73	2150.00	9	420.00				
	10	73	1840.00	21	55.00				
	11	73	1530.00	18	55.00				
	12	73	3080.00	16	2320.00				
	1	74	3960.00	5	4910.00	19	3040.00		
	2	74	3200.00	9	447.00	24	3280.00		

TRIBUTARY FLOW INFORMATION FOR NORTH CAROLINA 10/21/75

LAKE CODE 3710 LOOKOUT SHOALS RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3710B1	3	73	25.00	24	15.00				
	4	73	20.00	15	14.00				
	5	73	19.00	20	11.00				
	6	73	11.00	23	12.00				
	7	73	9.00	24	8.00				
	8	73	7.00	19	6.70				
	9	73	5.00	9	4.60				
	10	73	5.60	21	4.80				
	11	73	4.60	18	3.90				
	12	73	14.00	16	7.20				
	1	74	14.00	5	14.00	19	6.80		
	2	74	13.00	9	16.00	24	15.00		
3710D1	3	73	325.00	24	195.00				
	4	73	370.00	15	190.00				
	5	73	260.00	20	160.00				
	6	73	160.00	23	165.00				
	7	73	110.00	24	105.00				
	8	73	130.00	19	220.00				
	9	73	72.00	9	70.00				
	10	73	77.00	21	65.00				
	11	73	78.00	18	65.00				
	12	73	200.00	11	128.00				
	1	74	195.00	5	195.00	19	100.00		
	2	74	175.00	9	225.00	24	180.00		
3710E1	3	73	52.00	24	30.00				
	4	73	61.00	15	29.00				
	5	73	41.00	20	25.00				
	6	73	25.00	23	19.00				
	7	73	16.00	24	16.00				
	8	73	20.00	19	35.00				
	9	73	11.00	9	11.00				
	10	73	12.00	21	10.00				
	11	73	12.00	18	10.00				
	12	73	34.00	16	10.00				
	1	74	21.00	5	30.00	19	14.00		
	2	74	19.00	9	35.00	24	28.00		
3710Z2	3	73	70.00						
	4	73	70.00						
	5	73	55.00						
	6	73	35.00						
	7	73	24.00						
	8	73	25.00						
	9	73	16.00						
	10	73	17.00						
	11	73	15.00						
	12	73	35.00						
	1	74	50.00						
	2	74	40.00						

APPENDIX D

PHYSICAL and CHEMICAL DATA

371001
[illegible] UNI 05 [illegible]
[illegible] [illegible]
375 55 [illegible]

TRIBALES
3

2111202
0055 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CONDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/03/30	15 50	0000	12.5		18	50K	7.30	10K	0.120	0.400	0.270	0.013
	15 50	0004	12.1	8.7		50K	7.20	10K	0.140	0.300	0.270	0.012
	15 50	0015	12.0	8.8		50K	7.60	10K	0.140	0.400	0.270	0.011
	15 50	0030	11.9	8.8		50K	7.60	10K	0.140	0.300	0.270	0.012
	15 50	0050	11.9	8.9		50K	7.70	10K	0.140	0.300	0.270	0.011
73/07/07	09 30	0000	26.9		60	60	7.10	18	0.090	0.400	0.170	0.009
	09 30	0005	25.7	7.5		55	6.80	17	0.090	0.200K	0.180	0.005
	09 30	0015	24.9	5.1		57	6.50	18	0.130	0.200K	0.180	0.005
	09 30	0040	23.7	4.7		55	6.50	19	0.150	0.300	0.180	0.009
	09 30	0060	22.5	1.2		60	6.30	23	0.330	0.500	0.160	0.006
73/09/24	11 10	0000	25.3	8.2	72	46	7.70	18	0.100	1.500	0.140	0.011
	11 10	0015	23.9	4.8		47	6.40	16	0.140	0.500	0.130	0.007
	11 10	0035	23.6	4.0		47	6.70	15	0.160	0.500	0.130	0.007
	11 10	0055	23.2	3.4		49	6.50	18	0.210	0.500	0.120	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/30	15 50	0000	0.034	1.7
	15 50	0004	0.027	
	15 50	0015	0.025	
	15 50	0030	0.025	
	15 50	0050	0.022	
73/07/07	09 30	0000	0.024	5.8
	09 30	0005	0.024	
	09 30	0015	0.023	
	09 30	0040	0.023	
	09 30	0060	0.044	
73/09/24	11 10	0000	0.025	11.4
	11 10	0015	0.020	
	11 10	0035	0.019	
	11 10	0055	0.021	

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

371002
35 45 30.0 081 08 00.0
LOOKOUT SHOALS
37035 NORTH CAROLINA

11EPALES 2111202
J 0015 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	[illegible] NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/03/30	16	25 0000	12.2		18	50K	7.60	10K	0.140	0.300	0.270	0.019
	16	25 0004	12.3	9.0		50K	7.60	10K	0.110	0.300	0.260	0.012
	16	25 0011	12.2	8.9		50K	7.60	10K	0.130	0.600	0.260	0.013
73/07/07	10	25 0000	23.2		40	55	6.70	20	0.210	0.400	0.200	0.008
	10	25 0005	22.8	4.8		55	6.50	12	0.180	0.200K	0.200	0.006
	10	25 0011	22.7	4.8		55	6.50	12	0.170	0.200	0.200	0.005
73/09/24	11	45 0000	23.6	4.8	37	48	6.60	19	0.170	0.700	0.140	0.008
	11	45 0004	23.5	5.0		49	6.40	19	0.150	0.400	0.120	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/30	16	25 0000	0.066	1.5
	16	25 0004	0.062	
	16	25 0011	0.061	
73/07/07	10	25 0000	0.024	2.0
	10	25 0005	0.019	
	10	25 0011	0.020	
73/09/24	11	45 0000	0.030	6.0
	11	45 0004	0.025	

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/10/20

3710A1 C3710A1
35 45 30.0 081 05 30.0
CATAWBA RIVER
37087 MAR IREDELL CO
0/LOOKOUT SHOALS RESVR
UNAMED RD BRDG BELO LOOKOUT SHOALS DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/24	10 15		0.220	0.270	0.070	0.021	0.050
73/04/15	12 00		0.241	0.350	0.066	0.017	0.045
73/05/20	11 55		0.154	0.230	0.063	0.012	0.045
73/06/23	09 20		0.134	0.500	0.132	0.005K	0.020
73/07/24	14 40		0.150	0.480	0.140	0.005K	0.025
73/08/14	09 45		0.140	0.970	0.231	0.005K	0.030
73/10/21	10 05		0.132	0.450	0.072	0.014	0.015
73/11/18	14 35		0.140	0.350	0.040	0.012	0.040
73/12/16	10 20		0.136	0.300	0.068	0.012	0.030
74/01/05	10 00		0.154	0.900	0.076	0.008	0.030
74/01/19	09 15		0.300	0.400	0.088	0.020	0.070
74/02/04	09 20		0.252	0.200	0.075	0.022	0.065
74/02/24	09 00		0.280	0.400	0.055	0.015	0.055

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

3710A2 LS3710A2
35 49 30.0 081 11 30.0
CATAWBA RIVER
37 MAP CATAWBA CO
1/LOOKOUT SHOALS RESVR
HWY 16 BRDG JUST BELO LAKE HICKORY DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/24	11 10		0.200	0.350	0.087	0.022	0.065
73/04/15	12 45		0.231	0.285	0.063	0.022	0.045
73/05/20	12 30		0.147	0.500	0.084	0.013	0.040
73/06/23	10 00		0.130	0.580	0.230	0.005K	0.020
73/07/24	20 30		0.138	3.200	0.273	0.005K	0.020
73/08/19	10 30		0.110	0.610	0.150	0.005K	0.025
73/10/21	10 45		0.089	1.250	0.154	0.013	
73/11/18	15 15		0.104	0.350	0.080	0.012	0.032
73/12/16	10 55		0.106	0.300	0.100	0.016	0.035
74/01/05	11 15		0.156	0.800	0.232	0.012	0.040
74/01/19	10 00		0.300	0.400	0.088	0.024	0.065
74/02/09	10 10		0.240	0.300	0.085	0.025	0.065
74/02/24	09 45		0.232	0.300	0.065	0.020	0.055

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

3710H1 LS3710H1
35 47 30.0 081 08 30.0
ELK SHOALS CREEK (CATAWBA CO)
37 MAP CATAWBA CO
T/LOOKOUT SHOALS RESVR
BRDG ON UNAMED RD 3 MI E OFHWY 16
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/24	10 45		0.250	0.140	0.013	0.015	0.030
73/04/15	12 20		0.160	0.580	0.020	0.026	0.050
73/05/20	12 15		0.105	0.320	0.018	0.008	0.025
73/06/23	09 35		0.260	0.270	0.050	0.009	0.025
73/07/24	20 05		0.240	0.420	0.066	0.011	0.040
73/08/19	10 10		0.240	0.600	0.072	0.011	0.040
73/10/21	10 25		0.115	0.900	0.042	0.017	
73/11/18	14 55		0.052	0.100K	0.016	0.012	0.020
73/12/16	10 35		0.240	1.100	0.052	0.016	0.030
74/01/05	11 00		1.600	0.700	0.276	0.016	0.030
74/01/19	09 35		0.300	0.700	0.044	0.012	0.025
74/02/04	09 45		0.240	0.100K	0.020	0.015	0.025
74/02/24	09 30		0.290	0.600	0.060	0.020	0.060

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

3710D1 LS3710D1
35 51 00.0 0H1 11 00.0
LOWER MIDDLE RIVER
37 MAP ALEXANDER CO
T/LOOKOUT SHOALS RESVR
BRDG ON UNNAMED CO RD IN MILLERSVILLE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/24	10 00		0.294	0.330	0.075	0.010	0.030
73/04/15	11 30		0.250	0.250	0.088	0.015	0.035
73/05/20	11 30		0.250	2.100	0.090	0.019	0.050
73/06/23	09 30		0.273	0.370	0.066	0.014	0.045
73/07/24	20 30		0.294	0.340	0.064	0.015	0.055
73/08/19	09 10		0.294	1.200	0.425	0.023	
73/10/21	09 30		0.231	0.500	0.054	0.048	
73/11/18	15 00		0.192	0.250	0.040	0.032	0.070
73/12/11	13 30		0.312	0.400	0.056	0.028	0.055
74/01/05	14 00		0.410	0.100	0.044	0.005K	0.015
74/01/19	09 30		0.352	0.100K	0.056	0.020	0.050
74/02/09	13 30		0.288	0.700	0.450	0.020	0.060
74/02/24	10 00		0.290	0.300	0.065	0.020	0.070

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/20

3710E1 LS3710E1
35 48 30.0 081 06 00.0
ELK SHOALS CREEK (ALEXANDER CO)
37 MAP ALEXANDER CO
T/LOOKOUT SHOALS RESVR
BRDG ON RD 1.9 NW IREDELL-ALEXANDER CO L
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/24	10	35	0.168	0.180	0.025	0.006	0.025
73/04/15	12	20	0.140	0.190	0.033	0.007	0.015
73/05/20	12	10	0.138	1.640	0.140	0.006	0.020
73/06/23	10	15	0.168	0.425	0.048	0.005K	0.025
73/07/24	20	00	0.260	1.600	0.490	0.011	0.070
73/08/19	09	55	0.160	0.190	0.013	0.005K	0.035
73/10/21	10	00	0.115	0.800	0.031	0.015	
73/11/18	14	30	0.088	0.100K	0.016	0.012	0.020
73/12/19	14	30	0.148	0.200	0.060	0.005K	0.015
74/01/05	13	00	0.280	0.200	0.044	0.005K	0.020
74/01/19	10	15	0.224	0.700	0.072	0.005K	0.035
74/02/04	14	25	0.184	0.400	0.095	0.005	0.020
74/02/24	10	20	0.192	0.300	0.047	0.005K	0.040

K VALUE KNOWN TO BE
LESS THAN INDICATED